

Solar Battery Charger

By

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Chapter 1

DESIGN BACKGROUND AND INTRODUCTION

Introduction

One of the least tapped sources of energy is the solar energy. Solar energy is free and does not create harmful by-products. The Philippines is one of best places to harness this form of energy because it is located near the equator. Being a tropical country, exploiting the powers of the sun is very advantageous for the people. The team would like to use this form of energy by transforming it into electricity that would be used by a particular device.

As of April 24, 2008, Meralco, as the largest electricity provider in the Philippines, announced that it was raising its rates. (This was another factor why the team conducted this research design. Aside from saving on their electric consumption to keep their electric bill low, people can save further by using solar energy to charge their devices. This alternate energy source is even free of charge. Solar cell is a key device that converts the light energy into electrical energy in photovoltaic energy conversion. This was the reason why the research team chose solar cell to be the main part of the prototype.

Mobile devices (and other devices such MP3 Player and MP4 Player) are everywhere but oftenly, people find themselves lacking battery supply for their gadgets. This usually happens when an electrical battery charger is nowhere to

be found, or there is no available electrical outlet where a low battery can be recharged. (Soga, 2006).

Review of Related Literature

The Technology of Flat Plate Collectors

Of all the applications of solar energy, the use of flat plate collectors in heating is the most practical. The solar liquid heater was invented by H.B. Saussure during the second half of the 17th century; Herschel (1837) and Tellier (1885) also experimented on solar water heaters. Even in earlier times, the indigenous people of Africa, the Arab countries, Australia, China, India and Pakistan used their ingenuity in heating water by placing a specially shaped copper pot filled with water in the sun during the winter. Air heaters, however, are of recent invention. K.W. Miller introduced the overlapped glass plate air heater in 1943. Nowadays, it is cheaper to use solar water heaters for domestic appliances, and as such they are used all over the world.

From 1960 onwards, flat plate collectors have had the biggest share in research and development. This paper outlines the capabilities and limitations of such devices, with the intention of promoting the proper use of flat plate collectors, especially in developing countries. (Dixon and Leslie, 1979).

Characteristics of the Components of Flat Plate Collectors

A flat plate collector normally consists of an absorber, which is made of blackened metal – usually copper – and a grid of pipes soldered to the absorber. The assembly is placed in a box with insulation at the back of the absorber and one or two transparent covers at the top to allow sunlight in.

Material	Approximate Density (kg/m ³)	Thermal Conductivity (Wm ⁻¹ °C ⁻¹)
Mineral wool (clay, fiberglass, rock)	12-14	0.0332-0.0404
Hair Felt	80	0.0389
Granulated Cork	120	0.0476
Re-granulated cork (0.474 cm particles)	30	0.04471
Compressed cork	136-176	0.0418-0.0462
Straw	10-13	0.0576
Sawdust	13-240	0.0649
Vermiculite (granulated)	128	0.0721
Polyurethane foam (rigid)	24	0.0245
Polystyrene (expanded)	16	0.0303

Table 1. Properties of Commonly Used Insulation Materials

The properties of commonly used insulation materials are shown in Table 1. Plastic materials, such as PVF, and fiberglass sheets, have been used in solar heaters, but they are in general inferior to glass because they deteriorate with time and at high temperatures. Moreover, ultraviolet radiation discolors them. The plastic cover is, however, easier to handle than the glass cover.

The theoretical analysis for a flat plate collector is well established and can be summarized in the equation: $Q_o = Q_a - Q_L$, where Q_o is the power output, Q_a is the power absorbed by the collector, and Q_L is the power lost to the surroundings. The value of Q_a depends largely on the materials, of which the collector is made, and its coating and the solar angle of incidence. (Dixon and Leslie, 1979).

Practical Points

The following points should be noted with regard to the manufacture of flat plate collectors:

- a. poor adhesive is often used between the glass covers and the collector box. This is because it is preferable to let the pressure inside the collector gap be atmospheric so as to reduce convection and air conduction losses. This can only be achieved by not making the covers airtight. However, as a result, dust and moisture penetrate the collector and erode the surface of the absorber plate;
- b. insulation materials may contain moisture before they are used in the collector. As the collector gets hot, this moisture evaporates and condenses on the inside surface of the glass, and affects the incident radiation. It also corrodes the absorber plate;
- c. allowance must be made for glass expansion, and the edges of the collector must be beveled so that no rainwater collects on them;

- d. the collector should not be used without any liquid inside it. Otherwise, the high interior temperature generated will cause abnormal expansion that can distort or break the covers;
- e. in order to alleviate problems due to the freezing of water in tubes, a water/ethylene glycol solution can be used;
- f. the maximum area of a collector should be 2m^2 ; and
- g. to reduce the amount of infrared radiation escaping from the collector, specially coated glass covers can be used. This coating should be on the inside of the covers. (Dixon and Leslie, 1979).

CdS Thin Film Solar Cell

The CdS thin film solar cell is photovoltaic device made from a thin polycrystalline film of semiconducting CdS which is deposited on a suitable substrate. The essential features are: a substrate., a CdS layer, a barrier layer, and contacts. The substrate may be conducting or insulating, thin and flexible or thick and inflexible, transparent or opaque. The CdS layer is usually formed by vacuum deposition and is generally but not necessarily between about 10 and 30 mhu in thickness with an average grain diameter on the same order. The grains are normally disposed with the optical axis approximately perpendicular to the substrate with "fibre axis" orientation. The CdS film is invariably n-type semiconducting with resistivity usually within about one order of 10 ohm-cm, and hall mobility in the plane of the film within about one order of $10\text{ cm}^2 / \text{V-sec}$. (Shirland, 1966).

Film Cell Construction

1. Backwall cells

Backwall CdS film cells can be made using either opaque or transparent substrates. With an opaque substrate, the rectifying electrode or the barrier layer must be deposited first and the CdS film is deposited as an over layer. A ceramic substrate is coated with a layer of Cu_2S and the CdS film evaporated onto it and contacted with a collector electrode at one edge. A sheet of copper is used as a substrate which may be oxidized or sulfided prior to CdS deposition. In c, the rectifying and ohmic electrodes are deposited as alternate stripes on a glass substrate and overcoated with the CdS. Even though the substrate may be transparent, it does not need to be , and hence, this is basically the same.

Cells of this type have all been relatively inefficient and have series resistance effects. While they may have been present, they do not appear to have been the major reason. It appears that the formation of a junction or barrier to CdS by the use of "dry" methods usually yields a poor cell.

2. Frontwall cells

The first frontwall CdS film solar cell was probably made by NADJAKOV, though it was probably not recognized as a frontwall cell at the time. Photovoltaic action probably occurred only within about a micron's distance from the rectifying metal electrode contact. Thus, the active area was exceedingly small and accounts for the very low currents obtained.

The first frontwall cells in the 1% efficiency range were constructed as shown in b, with a more or less continuous thin Cu_2S layer on the CdS contacted by conductive paint electrode stripes spaced about 3-4mm apart as mentioned earlier.

3. Frontwall-backwall combination cell

If suitable transparent conducting electrodes are used, it is evident that the cell could be made in such a manner that it could be illuminated from either or both directions. The first work along these lines was evidently done by RAVICH at Itek Laboratories. His cell structured was like that shown in Figure 6A. Th CdS film was formed onto SnO_2 coated glass substrates, and the barrier layer was contacted with an evaporated gold electrode.

Ravich also tried a comb-like metallic grid, photoformed in place on the substrate, instead of the SnO_2 layer. This was, however, not very satisfactory, because it could be made with only about 50% of the substrate surface uncovered. The gold film evaporated onto the barrier is compatible with the barrier electrically, but unfortunately, it is not very conductive unless it is made thicker, in which case it is not very transparent. This cell construction is severely limited in output by series resistance. (Shirland, 1966).

Performance

1. Power Output
2. Voltage Output

3. Current Output
4. Effect of Illumination Intensity
5. Time response
6. Effect of temperature
7. Spectral response
8. Stability

Conclusions and Future Possibilities

The CdS thin film solar cells described in this paper have not “flown” in space, and they have not been made in production. There is further development and engineering work required in order to qualify them for space and to develop the fabrication processes for mass production.

More than 800 cells have been made of the 50 cm² area size in the laboratory having conversion efficiencies greater than 4%. These cells have been shown to be inherently stable, thin, flexible, and relatively straightforward to fabricate. There is nothing apparent in the materials required or in the cell design or fabrication methods to indicate that they could not be made in real mass production at very low costs. It is appropriate therefore that we consider the possibilities for future improvements and explore potential applications for them. (Shirland, 1966).

Conceptual Framework

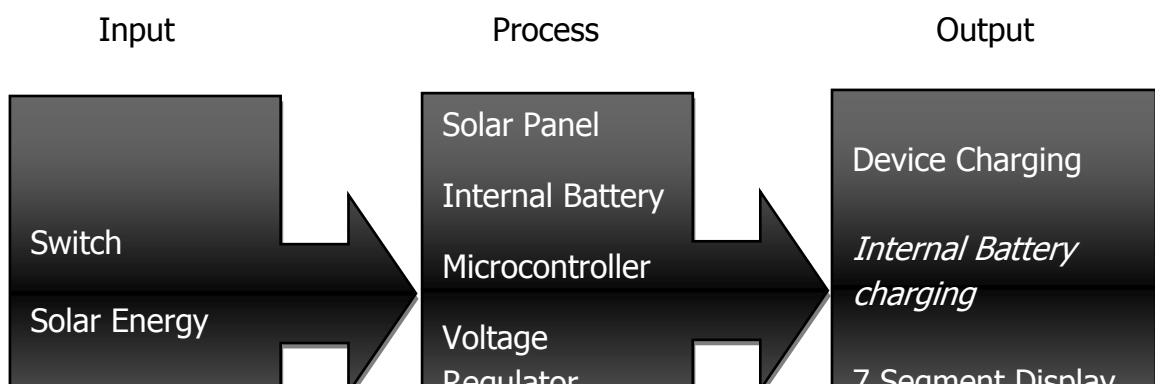


Figure 1. Conceptual Framework of the System

Figure 1 shows the conceptual framework of the system. It shows the inputs that are to be processed to come up with the desired output. The two inputs are the switch and the solar energy. The switch is used for turning the prototype design ON or OFF. The solar energy, on the other hand is the source of energy for this research design. It is used to charge either the device or the internal battery. With the use of these elements, the design prototype will activate and is ready to use.

During the process, the solar panel will collect the solar energy and will convert it to electrical energy. The electrical energy will be used to charge either the internal battery or the device, or both. If the user prefers to use the battery as the source for charging, the stored power from the battery will transfer to the device. If the user prefers to use the energy from the solar panel, the converted solar energy will be transferred directly to the device. During charging, either the user prefer to use the internal battery or the solar panel as the source, the microcontroller will respond and will be used as the voltmeter that will read the voltage being supplied to the device. The potentiometer will serve as the voltage selector. Using the switch, the user can select the voltage supply either fixed or varied.

As the output, the seven-segment will display the voltage read by the voltmeter. The processed energy will charge the device. If the user prefers to charge the internal battery alone, a LED will activate; this indicates that the internal battery is being charged.

In case the user prefers to use the internal battery or the solar panel as the source yet there is not enough energy, definitely, the device will not charge.

Statement of the Problem

As of today, the most prominent problem that the country faces is the price increase of basic necessities such as petroleum, water, food and electricity. With the price increase, people resort to alternatives to make the cost of living cheaper. Given this premise, the research team desired to help people cheapen their cost of living by reintroducing solar energy as an alternative to electrical energy in some cases.

Solar energy is a great alternative for power because it is renewable and free. With the device that the researcher created, solar energy could now partially resolve the problem in electricity usage.

Objective

The objective of this project design was to create a prototype of a solar battery charger, preferably for AA rechargeable batteries, and some mobile devices. A USB port adaptor was included in order to charge mobile devices such

as Nokia cellphones, MP3 players, and other devices utilizing the same voltage range and ports. Due to the uncertainty of receiving full charging capacity from the sun, an internal battery would be charged to supply additional emergency voltage. Using a PIC microcontroller, the team would designed a voltmeter. The voltmeter would be used to indicate the voltage output of the charger to the user. Together with a voltage regulator, this would prevent supplying the load with incorrect voltage.

Utilizing solar panels with a charger would make the voltmeter very versatile and mobile device. It can be charged almost anywhere for as long as it is exposed to direct sunlight over a period of time. If under less optimal weather condition, internal batteries will still ensure that the charging continues.

The research team worked on this study for the benefit of mobile appliance owners. The study was meant to supply the owners with information that could benefit them. The study would provide them with an almost unlimited source of energy for their electronic devices even during less sunny days or under bad weather condition.

Significance of the Design

This design would help people, especially Nokia cell phone users, and the users of other devices utilizing the same voltage range and ports, to save money at the same time utilize energy that is nature-friendly. As students, this

project design is very important because through this study, the team members were able to apply and practice their technical skills and accumulated knowledge and learning's. This prototype was also created to minimize the expenses of the people especially during these times when the price of electricity keeps on soaring.

Scope and Delimitation

The study was concerned with the development of a design called Solar Battery Charger that would serve as alternative to or replacement for the electric battery charger available in the market. The research study set the scope and delimitation as follows:

The scope:

1. The prototype is able to charge batteries that require 1V-17V recharge.
2. Devices such as cell phone, MP3 and PDAs are the devices that solar battery charger can charge.
3. A voltmeter is also attached to the said device to monitor the voltage that is being supplied to the system.
4. Internal battery is included to allow the unit to store energy that is very useful at times when there is less or no solar energy due to charging weather condition.
5. LED indicators are included as to show if there is voltage running in the system and if the internal battery is charging.

The delimitation:

1. It can only charge devices like cell phone, MP3 player, MP4 player and others devices that require voltage range from 1V-17V to charge.
2. It only charge internal battery if the solar panel provides 12V or higher.
3. Chargers that are suitable for cigarette phone jack are the only ports that the solar battery charger can provide.
4. Solar battery charger cannot be used during night time unless the internal battery is fully charged to support the voltage needed by the device to recharge.

Definition of Terms

Adaptor is a device connecting electrical appliances to a single socket.

(Oxford, 2007)

Battery a device containing an electrical cell or cells used as a source of power.

(Oxford, 2007)

Capacitor is a passive element designed to store energy in its electric field, the most common electrical components. It is consisted of two conducting plates separated by an insulator (or dielectric). It is an open circuit to dc used extensively in electronics, communications, computer, and power systems.

(Alexander and Sadiku, 2003)

Cellphone is a mobile phone. (Oxford, 2007)

Charge is meant to store electrical energy in a battery; electricity existing naturally in a substance. (Oxford, 2007)

Charger is a device for charging a battery. (Oxford, 2007)

Heatsink is an environment or object that absorbs and dissipates heat from another object using thermal contact (either direct or radiant). Heat sinks are used in a wide range of applications wherever efficient heat dissipation is required. (Podbieksi, 1999)

LED (Light Emitting Diode) is a type of diode that emits light when there is forward current. (Floyd, 2002)

PIC Microcontroller (Programmable Integrated Circuit) is a family of Harvard architecture microcontrollers made by Microchip Technology; it is derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. (Podbieksi, 1999)

Photovoltaic module is a packaged interconnected assembly of photovoltaic cells. (Podbieksi, 1999)

Potentiometer is a three-terminal device that operates on the principle of voltage division. It is essentially an adjustable voltage divider. As a voltage regulator, it is used as a volume or level control on radios, TVs and other devices. (Alexander and Sadiku, 2003)

Rectifier Diode is a semiconductor device that converts ac into pulsating dc; one part of a power supply. (Floyd, 2002)

Resistor is the simplest passive element. It is a device that has the ability to resist the flow of electric current that is measured in ohms. It is usually made from metallic alloys and carbon compounds. (Alexander and Sadiku, 2003)

Solar is the energy of the sun. (Podbieksi, 1999)

Solar Cell is a device that converts solar energy into electricity by the photovoltaic effect. (Podbieksi, 1999)

Solar Energy refers to the utilization of the radiant energy from the sun. (Podbieksi, 1999)

Toggle Switch is a class of electrical switches that are actuated by a mechanical lever, handle, or rocking mechanism. (Podbieksi, 1999)

Transistor is a semiconductive device used for amplification and switching applications. (Floyd, 2002)

Voltage Regulator keeps a constant dc output voltage when the input or load varies within limits. (Podbieksi, 1999)

Voltmeter is an instrument for measuring voltage. (Podbieksi, 1999)

Chapter 2

DESIGN METHODOLOGY AND PROCEDURE

Design Methodology

This research used structural methodology. Structural methodology is a process that follows the design procedure. In this case, the research was started by determining the problem. It was followed by reviewing related literature and studies and conceptualizing and developing the design. Figure 2 (on the next page) shows the procedure in developing the design. On the succeeding pages, Figure 3 shows the block diagram of the solar battery charger and Figure 5 shows the detailed functions of the solar battery charger.

Design Procedure

Figure 2 shows how the research study was done. The first step was to identify the problem that was how to charge cell phone and other devices with the same voltage range using the solar energy. After identifying the problem, relevant data were gathered to support the study, such as related literature and studies. These literature and studies were revised. Information useful to the design was recorded. When the data needed in the study were already substantial, possible solution to the problem was outlined. This was followed by gathering information about the materials and components to be used and checked again as to its usefulness and suitability as far as the design was concerned. When all the needed materials and components were gathered, the development and creation of the design started.

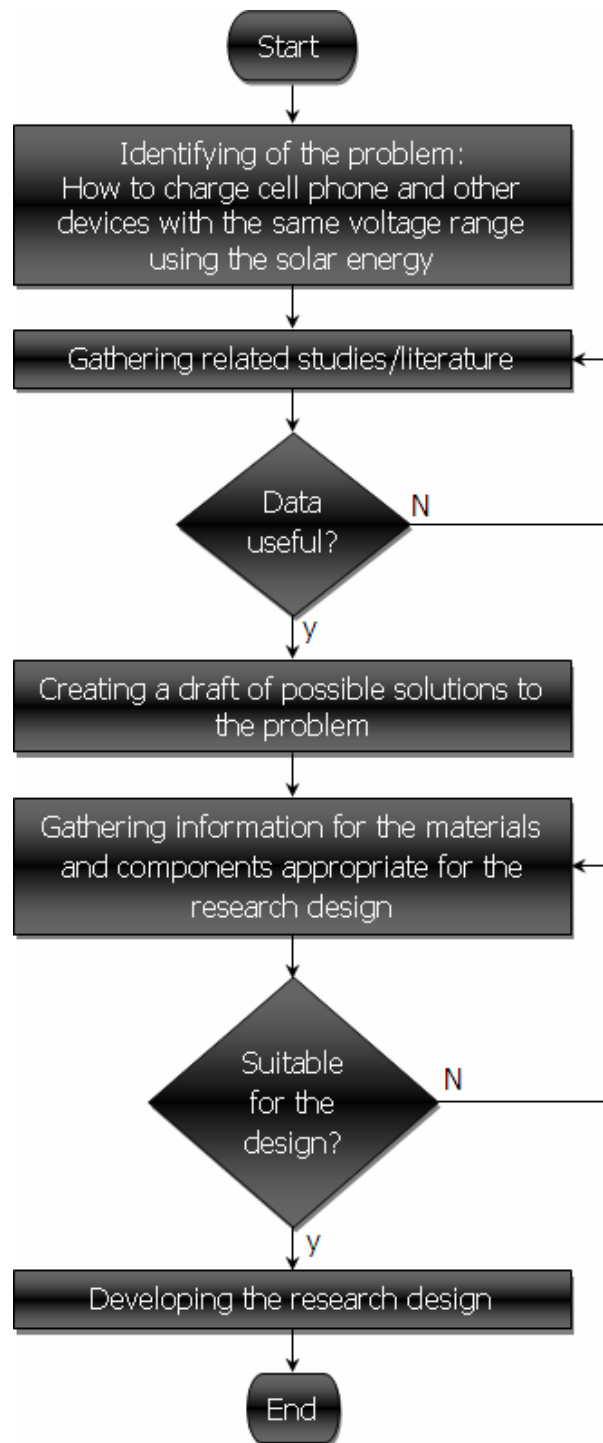


Figure 2. Design Procedure

Design Procedure for Actual Design

The design was started by researching on and finding the materials components suitable for the creation of the prototype. The appropriate products to be used were identified through data sheets researched on other related documents.

The detailed steps in constructing the research design are as follows:

1. Develop the PCB layout of the solar battery charger using the PCB Wizard software. Print the PCB layout in acetate.
2. Cut the printed circuit board in 3"x3.5".
3. Place the printed acetate (with PCB layout) at the top of printed circuit board. Expose it to UV light for about 30 seconds up to 1 minute.
4. Dissolve right amount of developer in water and place the exposed printed circuit board etch the circuit layout.
5. When the circuit layout is clear and visible, wash the printed circuit board with water to avoid continuous etching.
6. Place the etched printed circuit board to ferric chloride to dissolve unwanted copper in the board by shaking the container. When all unwanted copper is removed, wash the board with water and dry.
7. Test all the connections of copper layout using the VOM.
8. When all connections are tested and found correct, drill the board according to the placement of the components.
9. Mount all the components to the board except for the microcontroller.

10. Solder all components to the board. Make sure that the lead is big enough to hold and connect the component to the board, but not too big to avoid unwanted connection.
11. Test the function of the prototype.
12. Create a program for the specific function of the microcontroller which is voltmeter. Using assembly language, encode the program and with MPASM, convert the program to machine code.
13. Burn the code to the microcontroller.
14. Place the microcontroller to the board.
15. Drill the plastic case and place other components that are supposed to be expose such as the potentiometer, three-digit seven-segment display, cigarette phone jack, toggle switches, and the LED indicator.
16. Solder all remaining connections.
17. Test and troubleshoot the prototype.

The solar battery charger has built-in voltmeter. The solar panel was designed to be detachable to make the prototype easy to carry. The solar battery charger has two switches; one that selects the source for charging either solar panel or internal battery, and the other that selects if the voltage being supplied is fixed or variable. The solar battery was equipped with 7805 voltage regulator that could control the flow of voltage being supplied to the device. The PIC microcontroller was used as the voltmeter of the system. It could detect the

voltage being supplied and could display its value by the use of 3-digit 7-segment display.

The prototype circuit was created for the whole design and was tested. The microcontroller was programmed using assembly language. The program was encoded through serial programming and compiled it using the MPASM compiler that is downloadable and free. After compiling, the machine code was burned to the PIC16F877. Testing and debugging for both programs and electronic circuit were done afterwards. Circuit layout was created by photosynthesizing. The design was completed by fitting the components inside the casing. The solar battery charger was built by following the circuit diagram in Appendix A.

Hardware Design

The whole prototype was basically powered by the solar energy that was collected and converted into electrical energy by the solar panel. Once the solar panel collected enough energy to charge the internal battery, the battery could be used as the source to charge the device. The battery could provide up to 12V to charge a device. on the other hand, the device could also charge using the solar panel. The solar panel could provide up to 17.3 V depending on the intensity of sunlight.

The voltage regulator would controlled the voltage entering the device.
The voltage rate would be read by the microcontroller and would act as the
voltmeter that would display the voltage reading through seven segment displays.

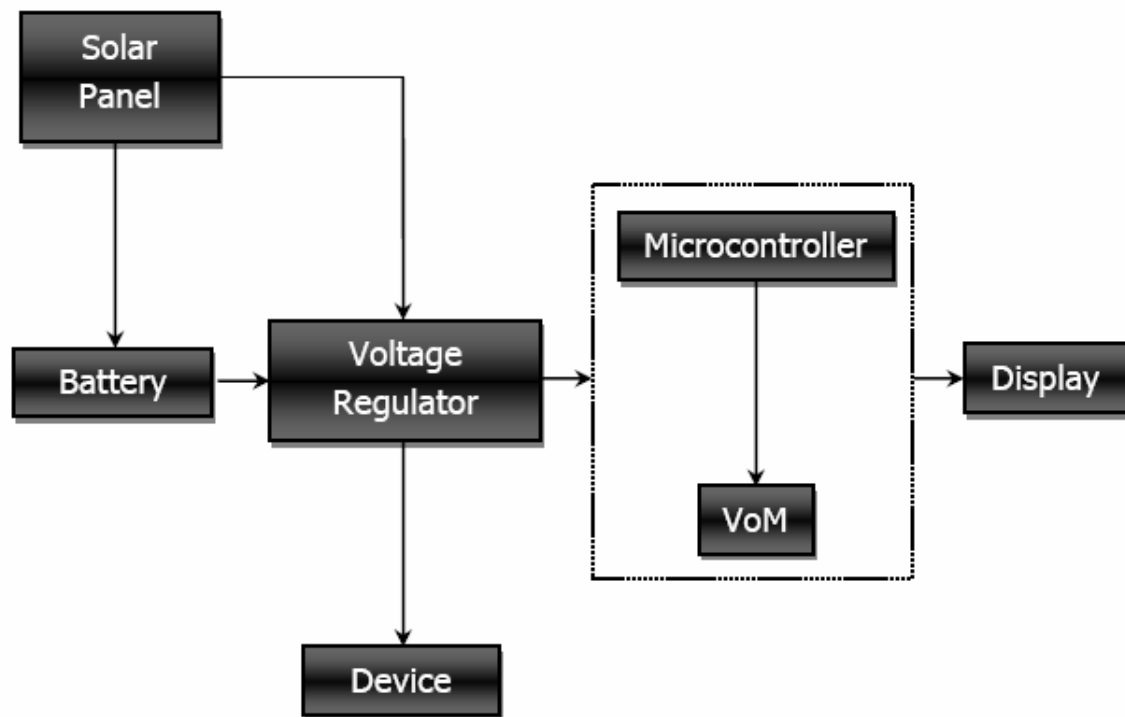


Figure 3. Block Diagram of the Hardware Design

List of Materials

Description	Quantity	Price per Unit	Total
PIC16F877	1	Php 530.00	Php 530.00
10K Array Resistor	2	Php 12.00	Php 24.00
4MHZ External Resonator	1	Php 35.00	Php 35.00
W10G Rectifier Diode	1	Php 10.00	Php 10.00
2 Pins Terminal Block	1	Php 15.00	Php 15.00
7805 Voltage Regulator	1	Php 15.00	Php 15.00
Heatsink	1	Php 20.00	Php 20.00
10 μ F / 16V Capacitor	1	Php 3.00	Php 3.00
2907 Transistor	6	Php 3.00	Php 18.00
1200 μ F / 16V Capacitor	1	Php 6.00	Php 6.00
Assorted 1/4 W Resistor	15	Php 0.25	Php 3.75
Toggle Switch	2	Php 18.00	Php 36.00
Potentiometer	1	Php 38.00	Php 38.00
3 Digits 7 Segment LED	1	Php 65.00	Php 65.00
Battery Holder 3x3	1	Php 45.00	Php 45.00
Battery Holder 2x2	1	Php 30.00	Php 30.00
Plastic Case	1	Php 125.00	Php 125.00
Solar Panel	1	Php 4,000.00	Php 4,000.00
Cigarette Phone Jack	1	Php 80.00	Php 80.00
Cigarette to Battery (Alligator)	1	Php 50.00	Php 50.00
Cigarette to Battery Nokia Charger	1	Php 100.00	Php 100.00
Cigarette to Battery USB	1	Php 100.00	Php 100.00
Connecting Wires	5m	Php 25.00	Php 25.00
Printed Circuit Board	1	Php 50.00	Php 50.00
Total			Php 5,423.75

Table 2. List of Materials

Hardware Component

The solar battery charger alone is basically composed of solar panel, diode, internal battery, capacitor, switch, voltage regulator, potentiometer and cigarette phone jack. The solar panel collects solar energy and converts it to electric energy. A diode is placed after the solar panel to avoid feedback effect of the electric charge. Feedback effect may happen once the charge of internal battery is greater than the energy that the solar panel is providing. The internal battery is placed to serve as storage and source of energy. Capacitors are used to check if the energy flowing to the system is DC or AC. Switches are used to switch ON or switch OFF the prototype and are also used to select the function of the charger, select panel or internal battery as a source, and select if the voltage produced can be varied or fixed. Once the user prefer to use the charger with a specific voltage rate, that is the time the voltage regulator is used, thru the help of the potentiometer. Finally the cigarette phone jack is used as the outlet for charger that the user prefers to use.

Aside from the charger, the prototype also has built-in voltmeter. The voltmeter is basically composed of array resistors, crystal capacitor, microcontroller and the 7-segment-display. The array resistors convert the ac to dc. The crystal defines the operating frequency of the microcontroller. The microcontroller processes the inputs from the array resistors and crystal. The output will be displayed using the 7-segment-display.

Circuit Design

Figure 4 shows the circuit diagram of the whole prototype design.

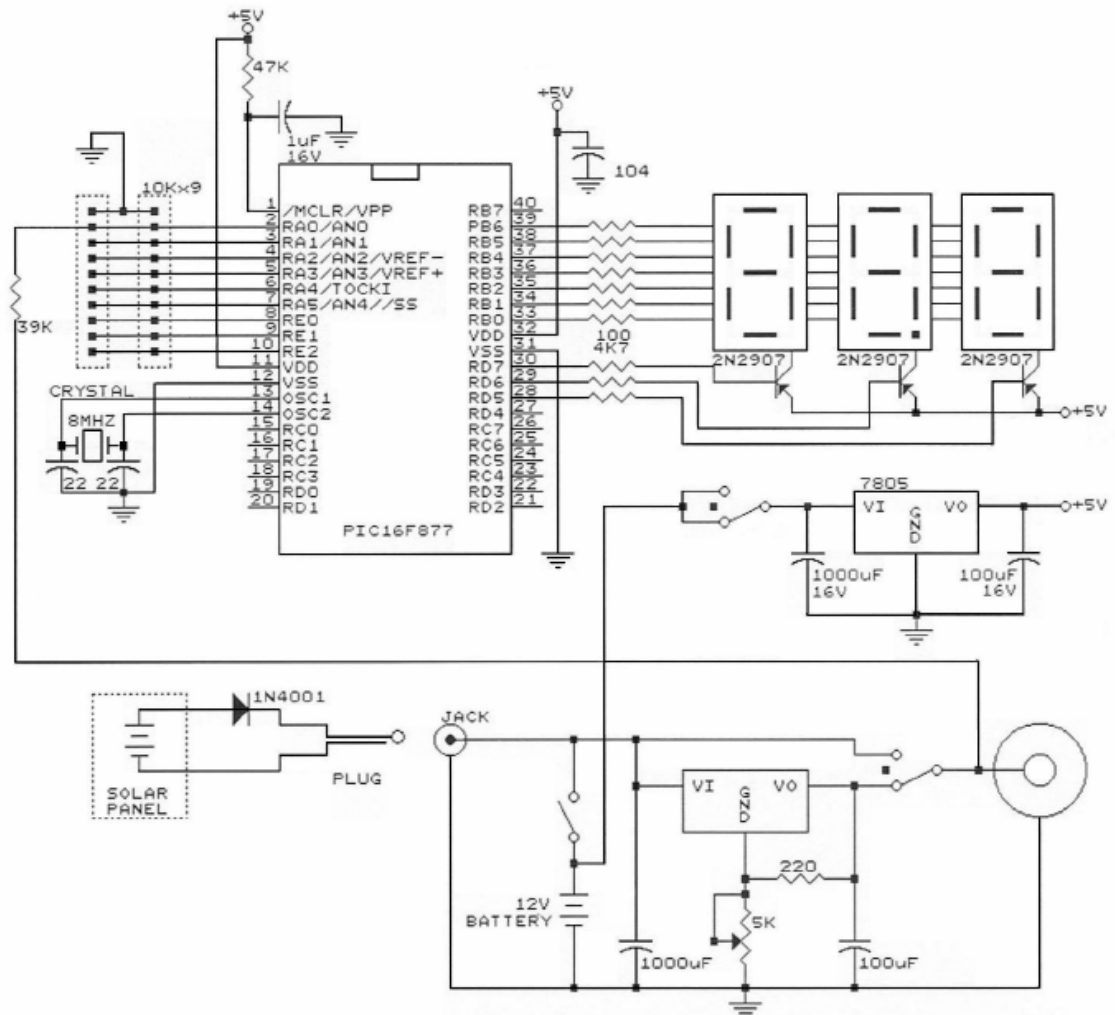


Figure 4. Schematic Diagram of Solar Battery Charger

The solar panel that collects and converts the solar energy to electrical energy can be detached from the system. This is done to make the prototype easy to carry. The prototype has two switches: one is for the source selector and the other is for the voltage selector, whether it is fixed or variable. If the

user prefers to use the solar panel as its source for charging, the first switch should be turned off (open) so that the battery is not connected to the system. The solar panel must collect enough solar energy to be able to charge a certain device. The user still has the option whether he wants to use fixed value of voltage from the solar panel or vary it according to his requirements. The second switch is used to connect the system to the voltage regulator that is used to vary the voltage being supplied to the device. If the user prefers to use the internal battery, the first switch should be turned on (close) to connect the battery to the system. The device cannot be charged if the internal battery has no enough energy. Just like the solar panel as a source, the user still has the option whether he wants to use fixed value of voltage from the solar panel or vary it according to his requirements.

Basically, the solar battery charger can function without the microcontroller. The microcontroller functions as the voltmeter for the system. It detects the voltage that is being supplied to the device. The electric energy as the input is converted in binary code that is done inside the microcontroller and the program will manage how the data will be arranged to have the expected result or display.

Hardware Implementation

Upon completing the research study, the team designed the prototype; carefully chose devices needed to implement the prototype. After completing the prototype, the members troubleshooted and tested the design. They used different cell phone units to charge using the solar battery charger. MP3, MP4, and iPod were also used to test the charger. All units were successfully charged.

Software Design

The program for the microcontroller was meant just for the built-in voltmeter that could be found in the prototype. The program was created using assembly language programming, a low-level language that implements numeric machine code and other constants needed to program computer architecture. Actually the PIC microcontroller could be programmed using other languages but it is only assembly language that has the free-downloadable compiler available in the internet. The compiler, which is the MPASM, is already available in the internet provided by the manufacturer of the Microchip Technology Inc. for its microcontroller users. The microcontroller has its built-in converter that served very useful in this research design.

The on-chip debugger that was utilized worked as a special hardware and software for the PIC Microcontroller. The PIC Microcontroller that was used in the design contained a special on-chip logic supporting debugging functionality and provided In-Circuit Serial Programming capabilities.

The machine code, that was the assembly language compiled using MPASM, was burned to the microcontroller and the microcontroller was attached to the system of the design and it functioned as the built-in voltmeter.

Software Component

Basically, the assembly language and MPASM were used for programming the microcontroller. The design team considered the compiler first before the language because there were so many compilers, but not all of them were available in market, furthermore, it was deemed wise to use a compile that was free of charge. Since the MPASM is free of charge and downloadable, the members decided to use assembly language, since assembly is the language that the MPASM compiles. After programming, the program was compiled to machine language and the machine code was burned to the microcontroller.

System Flowchart

Figure 5 shows the system flowchart of the solar battery charger. The basic function of this prototype is to charge a device, such as cell phone and MP3. To start, the prototype must be turned ON. The user has the option if he wants to charge the device directly from the internal battery or the solar panel. Whether the user chooses solar panel or the internal battery as the source for charging the device, either of the sources must have enough energy to charge the device. In charging, the user still has the option if he wants to have fixed or variable voltage that will be supplied to the device.

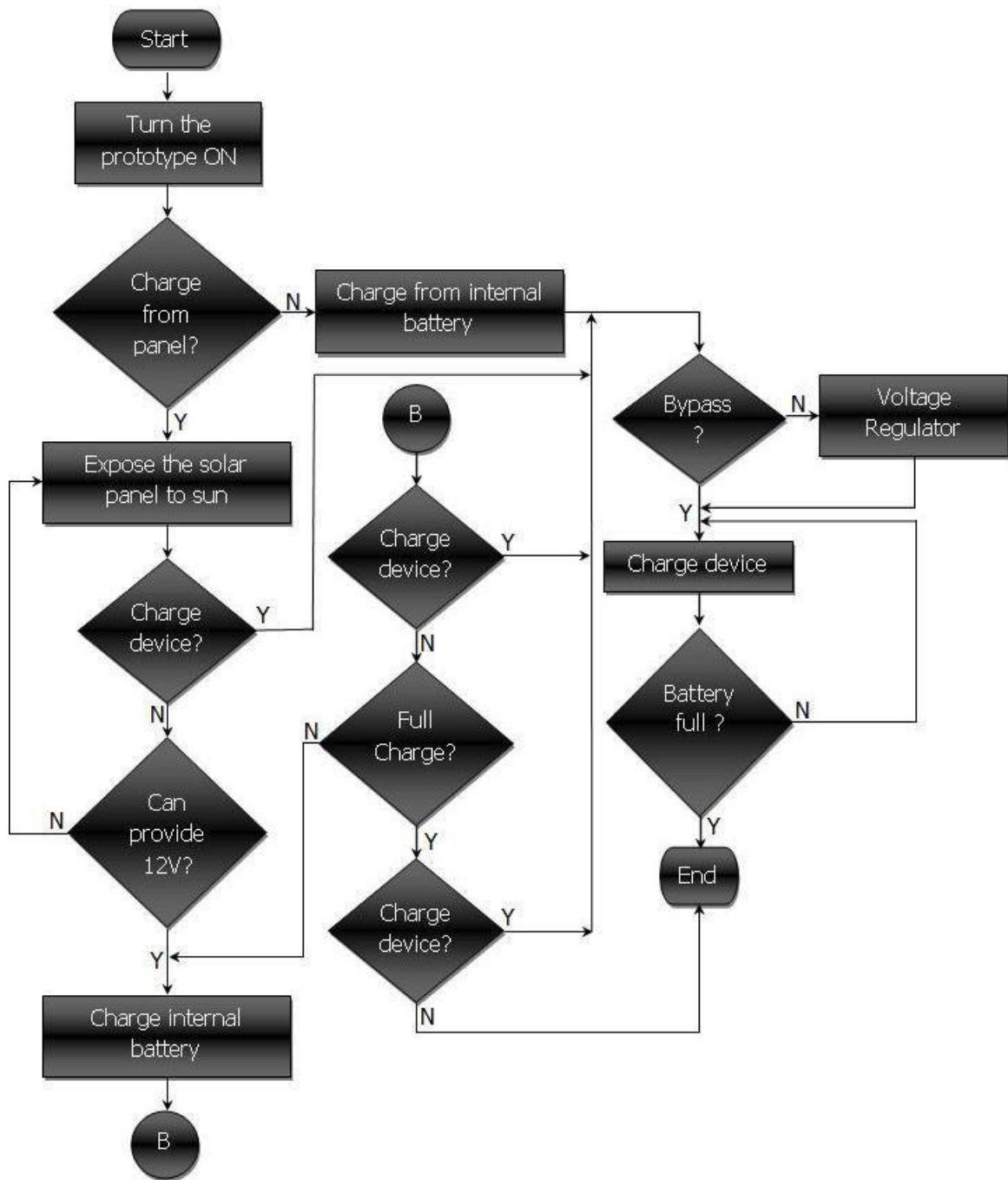


Figure 5. System Flowchart of Solar Battery Charger

Prototype Development

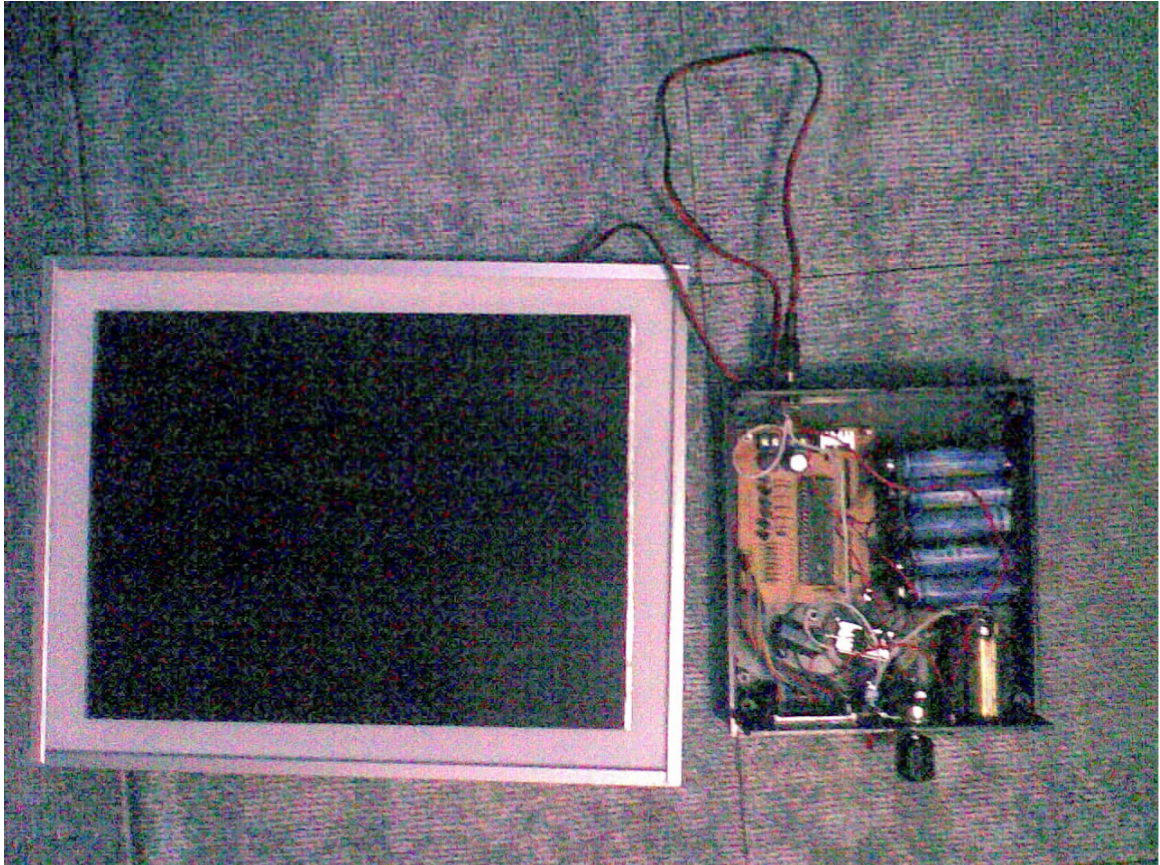


Figure 6. Actual Photo of Solar Battery Charger

Figure 6 shows the actual appearance of the solar battery charger. The prototype that the group developed is an actual size prototype. All components were carefully chosen to produce an efficient prototype. From researching, designing, developing up to testing, the group carefully gathered data and implemented the design accordingly. Other actual photos of the prototype are presented on the Appendix E.

Chapter 3

TESTING, PRESENTATION, AND INTERPRETATION OF DATA

The Solar Battery Charger was tested using VOM. Although the research design has a built-in voltmeter, this was done to assure the reliability and efficiency of the prototype. Since there are four functions that the prototype can provide, there were also four testing done; one was having solar panel as source with fixed value of voltage supply; two is having solar panel as source with variable value of voltage supply; three is having internal battery as source with fixed value of voltage supply; and four is having internal battery as source with variable value of voltage supply.

The following steps were done to come up with the results:

1. To get the voltage that was collected by the solar panel, tap the VOM was tapped directly to the solar panel connector. The VOM reading was recorded.
2. To get the value for Built-in Voltmeter Reading, switch the regulator switch was switched on to bypass to get the fixed value and the reading of the built-in voltmeter was examined.
3. The voltmeter was tapped to the cigarette phone jack to get the voltage being supplied by the system to the device. The result was recorded on the voltmeter reading column.
4. To get the voltage that was supplied by the internal battery, tap the VOM was tapped directly to the internal battery connector. The VOM reading was recorded.

5. To get the value for Built-in Voltmeter Reading, the regulator switch was switched ON to regulate. The value was made varied then step 3 to 5 was repeated for every voltage reading of the built-in voltmeter.

Built-in Voltmeter Reading	Voltmeter Reading	Using Voltmeter Directly to the Solar Panel
24.2	17.5V	25.5V

Table 3. Solar Panel as Source with Fix Value of Voltage Supply

Table 3, presents the built-in voltmeter which displays 24.2V that is definitely high compared to the voltmeter reading that is 17.5V. This result occurred because voltage entering from the solar panel was also consumed by the other components of the system.

Table 4, on the next page presents the results when the group used the voltage regulator to monitor the voltage being supply to the system and device. As expected, there was a voltage drop and as the voltage regulator increased its voltage supply, the voltage drop also increased. Comparatively, the voltage reading of built-in-voltmeter was higher than the reading of the voltmeter used for testing. Due to voltage drop that was stated above.

Built-in Voltmeter Reading	Voltmeter Reading	Using Voltmeter Directly to the Solar Panel
1V	1V	23.9V
2V	1.2V	24.6V
3V	1.4V	23.9V
4V	1.6V	24.9V
5V	1.9V	24.6V
6V	2.2V	24.5V
7V	2.7V	23.7V
8V	3V	25.5V
9V	3.3V	25.3V
10V	3.7V	24.9V
11V	4.2V	24.5V
12V	4.5V	24.5V
13V	4.7V	23.9V
14V	5V	23.4V
15V	6V	23.2V
16V	7.8V	24.9V
17V	8.7V	24.9V
17V	9.2V	25.1V
17V	10V	25.1V
17V	9.3V	25.5V
17V	8.7V	23.6V
17V	9.7V	23.7V
17V	10.3V	24V
17V	8.6V	24.6V
17V	9.5V	24.3V
17V	8.9V	24.9V

Table 4. Solar Panel as Source with Variable Value of Voltage Supply

Built-in Voltmeter Reading	Voltmeter Reading	Using Voltmeter Directly to the Internal Battery
7.8V	3.8V	8.6V

Table 5. Internal Battery as Source with Fix Value of Voltage Supply

Just like Table 3, Table 5 shows the difference between the reading of built-in VOM and voltmeter and the actual voltage being supplied by the internal battery. Still, the built-in voltmeter displayed higher value than the actual voltmeter used. This result occurred because voltage entering from the solar panel was also consumed by the other components of the system.

Built-in Voltmeter Reading	Voltmeter Reading	Using Voltmeter Directly to the Internal Battery
1V	1.2V	4.7V
2V	1.2V	4.7V
3V	1.5V	4.7V
4V	2.1V	4.7V
5V	2.6V	4.7V
6V	2.9V	4.7V
7V	2.8V	4.7V
8V	2.9V	4.7V
9V	3.5V	4.7V

Table 6. Internal Battery as Source with Variable Value of Voltage Supply

Table 3, 4, 5, and 6 show the results of the testing the research design with voltmeter. As seen in Figure 4, which is the schematic diagram of the Solar Battery Charger, the voltage that was being sensed by the microcontroller, passed through the microcontroller itself and the two LED specifically the microcontroller that used 5V, at most, before it operated. Also the LED display use 2V to activate, since the system has 2 LED, which is equal to 4V. All in all, there was 9V, at most, that were used by the system before it was used by the device to charge. The same reason applied to other table. The difference between the built-in voltmeter and voltmeter readings was not more than 9V.

Noticeably, the value of the voltmeter reading that was directly connected to the solar panel varied from time to time. It was because the solar panel could not collect constant solar energy that was converted to electric energy. Those values have positive or negative 5% accuracy difference.

Table 7 shows the ampere that the solar battery charger can provide at a given time. Based on the table, from six in the morning, where the sun starts to provide solar energy, the ampere being supplied by the solar battery charger started to increase. From 290mA at six in the morning it increased to 380mA at one in the afternoon. 380mA is the maximum ampere that the solar battery charger can provide. After one in the afternoon, the ampere being supplied by the charger started to decrease.

Time	Amperes produced by the Solar Battery Charger
6:00 AM	290 mA
7:00 AM	300 mA
8:00 AM	310 mA
9:00 AM	320 mA
10:00 AM	340 mA
11:00 AM	350 mA
12:00 PM	360 mA
1:00 PM	380 mA
2:00 PM	370 mA
3:00 PM	350 mA
4:00 PM	340 mA
5:00 PM	310 mA
6:00 PM	300 mA

Table 7. Amperes Produced by the Solar Battery Charger in a Given Time

With the given information from Table 7, it was learned that the minimum ampere that the charger could provide was 290mA and the maximum was 380mA. The data were utilized to come up with Table 8 and Table 9. As presented in Table 7, at six o'clock in the morning, the solar battery charger could provide 290mA which is the minimum supply in the morning whereas at one in the afternoon, the solar charger could provide up to 380mA supply which was the maximum supply. It can be concluded therefore that one o'clock is the best time to use the solar battery charger. However, the users are encouraged to utilize the solar battery charger anytime. Table 8 shows the battery charging hours of any device with 290mA supply and Table 9 shows the battery charging hours of any device with 380mA supply. As observed, any device that used

380mA as supply charged faster than with 290mA supply. The group had the option to use rapid charger on Nokia battery only. As expected, the rapid charger unit charged faster than the ordinary charger unit.

Device / Battery Type	Capacity mAH	Time in hrs Capacity /290mA	
		Ordinary Charger	Rapid Charger
Ni-Mh AA	2400	8h 15m	4h
Nokia BL-5C	600	2h	1h
Nokia BL-4C	600	2h	1h
Nokia BL-4C	720	2h 30m	1h 20m
Noka6015i	950	3h 15m	2h
Nokia BLD-3	720	2h 30m	1h 20m
Nokia3285	550	2h	1h
Nokia BLS-2N	900	3h	1h 15m
Nokia BLB-2	840	2h 50m	1h 45m
Nokia BLB-3	1020	3h 30m	2h 10m
Nokia BLC-2	950	3h 30m	2h
Nokia BMC-2	1020	3h 30m	2h 35m
Nokia BMC-3	2280	8h	3h 40m
LG LGLP-AGKM	800	2h 45m	*
LG LGLI-AGKL	1200	4h 10m	*
HTC Touch XV6900	900	3h 10m	*
HTC BTR6900	1100	3h 45m	*
HTC BTE6900	1880	6h 30m	*
Ipod battery (60GB)	700	2h 30m	*
Ipod battery (30GB)	550	1h 50m	*
Apple Ipod 4th Gen	950	3h 30m	*
Apple Ipod 3rd Gen	600	2h	*
Apple Ipod 1st and 2 nd Gen mini series	400	1h 30m	*
Apple Ipod 1st and 2nd Gen	1600	5h 30m	*
Asus MyPal PDA Battery (3.7V)	1300	4h 30m	*
Asus PDA Battery (3.7)	1200	4h 10m	*
LCD MP3 player 1GB mini pocket size	Lithium	5h	*

Table 8. Battery Charging Hours with 290mA Supply

Device / Battery Type	Capacity mAH	Time in hrs Capacity /380mA	
		Ordinary Charger	Rapid Charger
Ni-Mh AA	2400	6h 15m	3h 30m
Nokia BL-5C	600	1h 30m	50m
Nokia BL-4C	600	1h 30m	50m
Nokia BL-4C	720	1h 45m	55m
Noka6015i	950	2h 30m	1h 20m
Nokia BLD-3	720	1h 45 m	55m
Nokia3285	550	1h 30m	50m
Nokia BLS-2N	900	2h 15m	1h 10m
Nokia BLB-2	840	2h 15m	1h 10m
Nokia BLB-3	1020	2h 30m	1h 20m
Nokia BLC-2	950	2h 30m	1h 20m
Nokia BMC-2	1020	2h 30m	1h 20m
Nokia BMC-3	2280	6h	3h
LG LGLP-AGKM	800	2h 10m	*
LG LGLI-AGKL	1200	3h 10m	*
HTC Touch XV6900	900	2h 15m	*
HTC BTR6900	1100	2h 45m	*
HTC BTE6900	1880	5h	*
Ipod battery (60GB)	700	1h 50m	*
Ipod battery (30GB)	550	1h 30m	*
Apple Ipod 4th Gen	950	2h 30m	*
Apple Ipod 3rd Gen	600	1h 30m	*
Apple Ipod 1st and 2nd Gen mini series	400	1h	*
Apple Ipod 1st and 2nd Gen	1600	4h 15m	*
Asus MyPal PDA Battery (3.7V)	1300	3h 30m	*
Asus PDA Battery (3.7)	1200	3hr10m	*
LCD MP3 player 1GB mini pocket size	Lithium	3hr	*

Table 9. Battery Charging Hours with 380mA Supply

*No battery rapid charger available

Chapter 4

CONCLUSION AND RECOMMENDATION

Conclusion

A device that could charge AA battery and other devices such as cell phone and MP3 player were created. The USB port adaptor was included to provide port to other devices such as MP4, PDAs and other more devices utilizing the same voltage range. The solar battery charger was able to charge the internal battery that served as alternative source especially at times that there was no available solar energy. It was learned that the designed device could provide up to 25.5 V if charged directly from the solar panel and 13.5 V if charged directly from the internal battery. Through testing, it was noted that the voltage value being displayed by the built-in voltmeter was higher than the actual voltage that was supplied to the device being charged. Specifically, there was atmost 9V difference between the actual voltage being supplied and the value being displayed by the built-in voltmeter. This 9V was the result of 5V being used by the microcontroller and 4V being used by 2 LEDs.

Recommendation

Several improvements can be applied to the device to further enhance its capabilities like calibrating the voltage entering the microcontroller to display the exact value that is being supplied to the device. Other improvements can be applied to the design for it to produce higher voltage rate so that it can also be

used as alternative energy source for laptops, computers, refrigerators and other electronic or electric devices that are commonly used.

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APPENDIX A

Circuit/Schematic Diagram

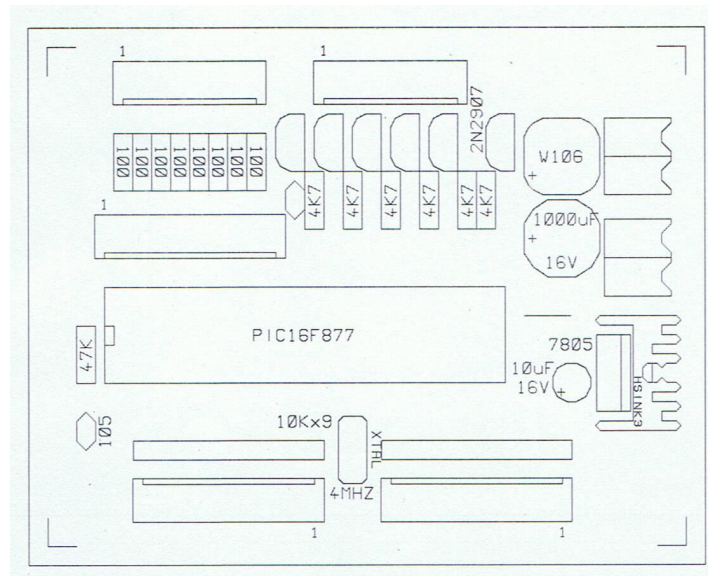


Figure 7. Block Diagram of Solar Battery Charger

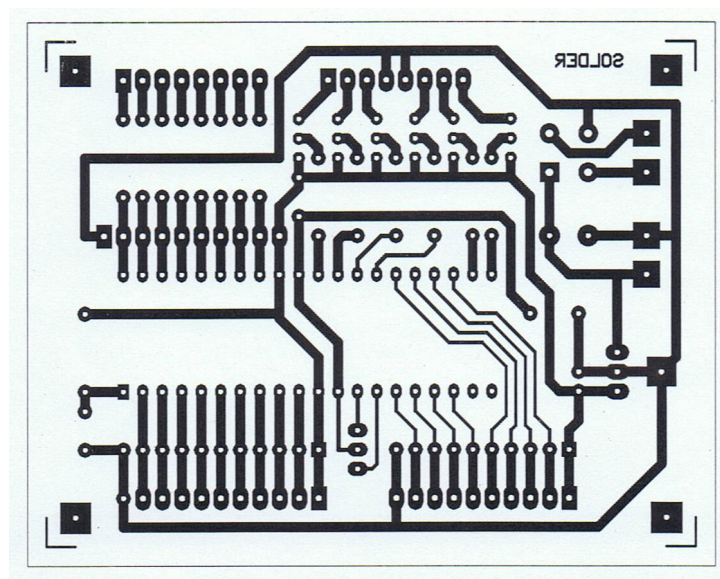


Figure 8. PCB Layout of Solar Battery Charger

APPENDIX B

Source Code

```
;*****
;
;           File SOLARBAT.ASM @4Mhz ceramic resonator
;
;           processor      16F877
;
;           include        <P16F877.inc>
;
;           __config _HS_OSC & _WDT_OFF & _PWRTE_ON & _LVP_OFF & _BODEN_OFF &
;           _CP_ALL
;*****
;
;           General Purpose RAM location: (STATUS-reg RP1/RP0: x__x
;           xxxx)
;
;           Bank_0: RP1/RP0 (00): 20H to 7FH (96 bytes)
;
;           Bank_1: RP1/RP0 (01): 20H to 6FH (80 bytes)
;
;           Bank_2: RP1/RP0 (10): 10H to 6FH (96 bytes)
;
;           Bank_3: RP1/RP0 (11): 10H to 6FH (96 bytes)
;
;           Note   : common access Bank_0 to Bank_3 : 70H to 7FH
;*****
;
;           Variable Declaration
;
;           ADC0_HI      equ    H'40'          ;
;
;           ADC0_LO      equ    H'41'          ;
;
;           Hundred      equ    H'42'          ;
;
;           Ten           equ    H'43'          ;
;
;           Unit         equ    H'44'          ;
;
;           Disp_Ctr     equ    H'45'          ;
;
;
;
;           Temp1        equ    H'78'          ; temporary variable.
;
;           Temp2        equ    H'79'          ;
```

```

Temp3          equ    H'7A'          ;
Temp4          equ    H'7B'          ;

;*****

;          Reset Vector Starts at Address 0x0000.

;*****

          org    0x0000          ; start of reset vector.

          goto   Initialize      ;

          ;

          org    0x0004          ; start of interrupt service
routine.

          goto   ISR_routine     ;

;*****

;          Initialization Routine.

;*****

          org    0x0008          ;

Initialize:     clrf   TMR0        ; Clear TMR0

               clrf   INTCON      ; Disable Interrupts and clear T0IF

               bcf    STATUS,RP1   ;

               bsf    STATUS,RP0   ; Select Bank 1

               movlw  B'11000011'  ;

               movwf  OPTION_REG   ;

               ;

               movlw  B'00001110'  ; Set AN0 Left Justified

               movwf  ADCON1        ;

               movlw  B'11111111'  ;          0=Out 1=In

               movwf  TRISA        ; Port A. 11xx xxxx: TTL

               ;

               movlw  B'00000000'  ;          0=Out 1=In

```

```

        movwf TRISB          ; Port B. xxxx xxxx:TTL
                                ;
        movlw B'00000000'    ;          0=Out 1=In
        movwf TRISC          ; Port C. xxxx xxxx:schmitt
                                ;
        movlw B'00000000'    ;          0=Out 1=In
        movwf TRISD          ; Port D. xxxx xxxx:schmitt
                                ;
        movlw B'00000111'    ;          0=Out 1=In
        movwf TRISE          ; Port E. xxxx xxxx:schmitt
                                ;
        bcf     STATUS,RP0    ; Select Bank 0
                                ;
        call    Init_Var      ;
;*****
Main:      call    Display      ;
          call    Delay        ;
          goto    Main         ;
;*****
;          The Interrupt Service Routine.
;*****
ISR_routine:  retfie          ; Return from Interrupt.
;*****
Seg_Table:   addwf   PCL,F      ;
              ; afbgc.de
          retlw   B'00010100'    ;0
          retlw   B'11010111'    ;1
          retlw   B'01001100'    ;2

```

```

        retlw B'01000101'        ;3
        retlw B'10000111'        ;4
        retlw B'00100101'        ;5
        retlw B'00100100'        ;6
        retlw B'01010111'        ;7
        retlw B'00000100'        ;8
        retlw B'00000101'        ;9
        retlw B'11111111'        ;A
        retlw B'11111111'        ;B
        retlw B'11111111'        ;C
        retlw B'11111111'        ;D
        retlw B'11111111'        ;E
        retlw B'11111111'        ;F
        ;
Init_Var:    clrf    PORTC        ;
            clrf    PORTB        ;
            bsf     PORTD,7        ;
            bsf     PORTD,6        ;
            bsf     PORTD,5        ;
            movlw   B'00000001'    ; 00xx x001
            movwf   ADCON0        ; select AN0 to convert
            clrf    ADC0_HI        ;
            clrf    ADC0_LO        ;
            clrf    Disp_Ctr        ;
            call    BIN2BCD        ;
            return                ;
;*****
Display:    bsf     PORTD,7        ;

```

```

        bsf     PORTD,6           ;
        bsf     PORTD,5           ;
                                   ;
Disp_100:  movf   Disp_Ctr,W       ;
        sublw   D'2'              ;
        btfss   STATUS,Z          ;
        goto    Disp_100X         ;
        movf    Hundred,W         ;
        andlw   H'0F'             ;
        call    Seg_Table         ;
        movwf   PORTB             ;
        bcf     PORTD,7           ;
Disp_100X: nop                    ;
                                   ;
Disp_010:  movf   Disp_Ctr,W       ;
        sublw   D'1'              ;
        btfss   STATUS,Z          ;
        goto    Disp_010X         ;
        movf    Ten,W             ;
        andlw   H'0F'             ;
        call    Seg_Table         ;
        movwf   PORTB             ;
        bcf     PORTB,2           ;
        bcf     PORTD,6           ;
Disp_010X: nop                    ;
                                   ;
Disp_001:  movf   Disp_Ctr,W       ;
        sublw   D'0'              ;

```

```

        btfss STATUS,Z          ;
        goto Disp_001X          ;
        movf Unit,W             ;
        andlw H'0F'             ;
        call Seg_Table          ;
        movwf PORTB             ;
        bcf PORTD,5             ;
Disp_001X:  nop                  ;
                                                ;
        incf Disp_Ctr,F         ;
        movlw D'3'              ;
        subwf Disp_Ctr,W        ;
        btfss STATUS,C          ;
        goto DisplayX           ;
        clrf Disp_Ctr           ;
        call Read_ADC           ;
        movf ADC0_HI,W          ;
        movwf Temp2             ;
        call BIN2BCD            ;
                                                ;
DisplayX:  return                ;
;*****
Read_ADC:  btfsc ADCON0,2        ; Test if ADC conversion ?Done
        goto Read_ADCX          ;
                                                ;
        movf ADRESH,W           ; get A/D result
        movwf ADC0_HI           ;
        movlw B'00000001'       ;

```

```

        movwf  ADCON0                ; ensure A/D is active
                                        ;

Start_ADC:    bsf      ADCON0,2        ; start A/D conversion
                                        ;

Read_ADCX:    return                  ;

;*****

BIN2BCD:      clrf     Hundred          ;
               clrf     Ten              ;
               clrf     Unit             ;
               ;
Inc_100:       movlw   D'100'           ;
               subwf   Temp2,W          ;
               btfss   STATUS,C          ;
               goto    Inc_010          ;
               movwf   Temp2            ;
               incf     Hundred,F        ;
               goto    Inc_100          ;
               ;
Inc_010:       movlw   D'10'            ;
               subwf   Temp2,W          ;
               btfss   STATUS,C          ;
               goto    Inc_001          ;
               movwf   Temp2            ;
               incf     Ten,F            ;
               goto    Inc_010          ;
               ;
Inc_001:       movf    Temp2,W          ;
               movwf   Unit             ;

```

```

;
return
;

;*****
Delay:    movlw  D'250'      ;
          movwf  Temp1      ;
Dly_Loop: decf   Temp1,F     ;
          movf   Temp1,W    ;
          btfss  STATUS,Z   ;
          goto   Dly_Loop   ;
          return            ;

;*****
end
;
;*****

```

APPENDIX C



PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

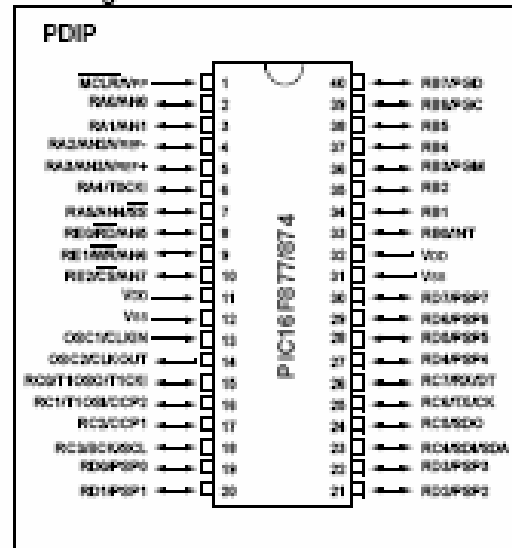
Devices Included in this Data Sheet:

- PIC16F873 • PIC16F876
- PIC16F874 • PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
Up to 368 x 8 bytes of Data Memory (RAM)
Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and
Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC
oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM
technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two
pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature
ranges
- Low-power consumption:
 - < 0.6 mA typical @ 3V, 4 MHz
 - 20 µA typical @ 3V, 32 kHz
 - < 1 µA typical standby current

Pin Diagram

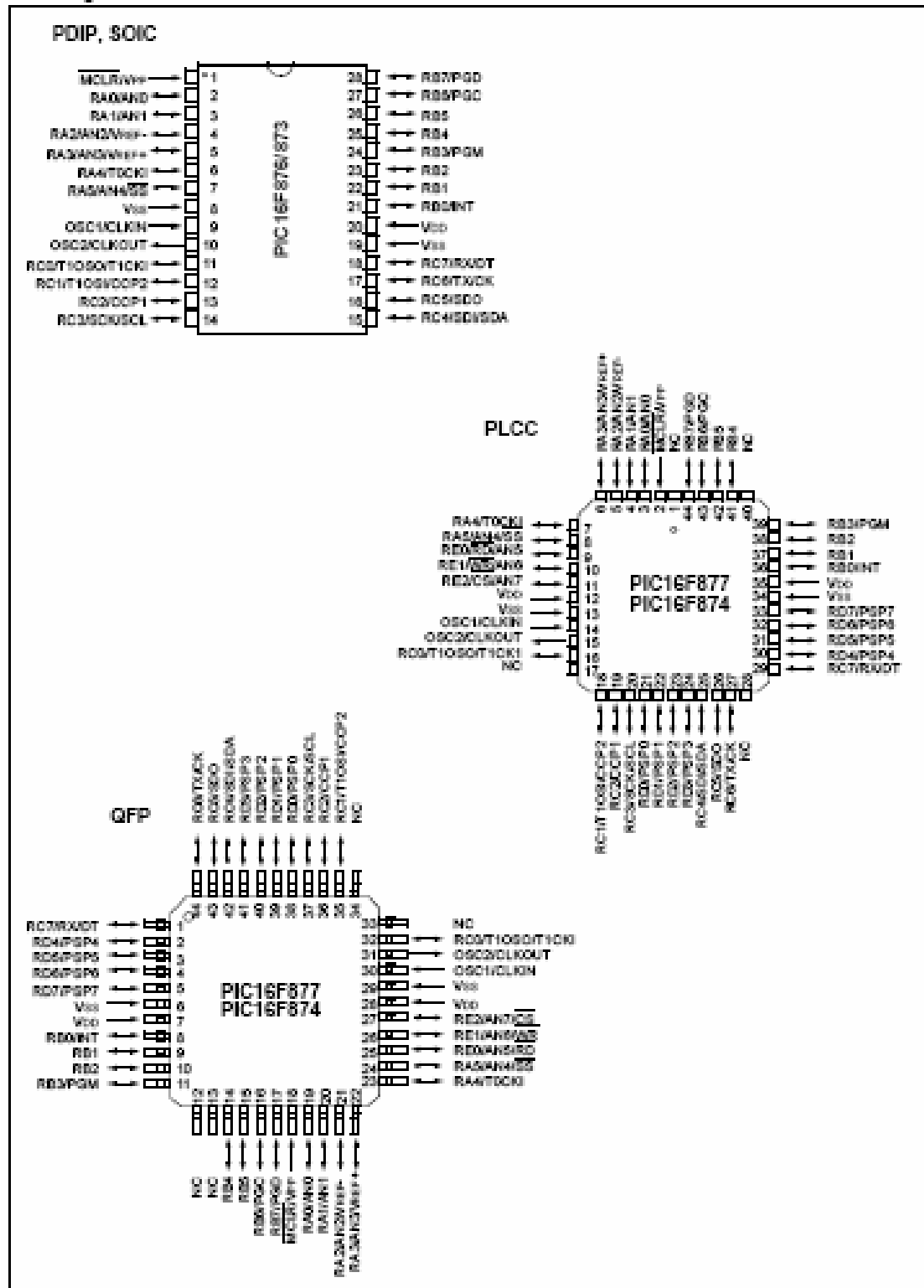


Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler,
can be incremented during SLEEP via external
crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period
register, prescaler and postscaler
- Two Capture, Compare, PWM modules
 - Capture is 16-bit, max. resolution is 12.5 ns
 - Compare is 16-bit, max. resolution is 200 ns
 - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master
mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver
Transmitter (USART/SCI) with 9-bit address
detection
- Parallel Slave Port (PSP) 8-bits wide, with
external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for
Brown-out Reset (BOR)

PIC16F87X

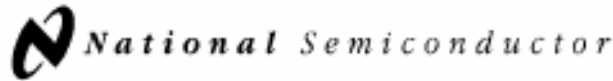
Pin Diagrams



PIC16F87X

Key Features PICmicro™ Mid-Range Reference Manual (DS83023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (FWRT, OST)	POR, BOR (FWRT, OST)	POR, BOR (FWRT, OST)	POR, BOR (FWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	I ² C	—	I ² C
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 instructions	35 instructions	35 instructions	35 instructions

APPENDIX D



February 1995

LM78XX Series Voltage Regulators

General Description

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HFI, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expended to make the LM78XX series of regulators easy to use and minimize the number

of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

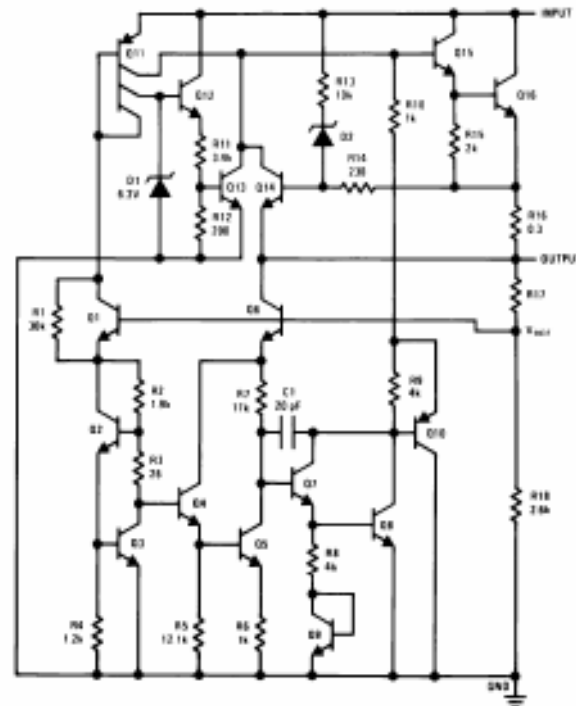
Features

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

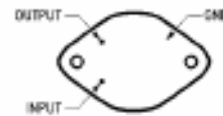
Voltage Range

LM7805C	5V
LM7812C	12V
LM7815C	15V

Schematic and Connection Diagrams



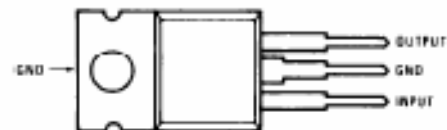
Metal Can Package
TO-3 (K)
Aluminum



Bottom View

Order Number LM7805CK,
LM7812CK or LM7815CK
See NS Package Number KC02A

Plastic Package
TO-220 (T)



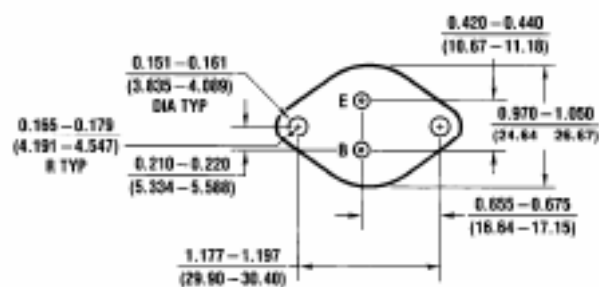
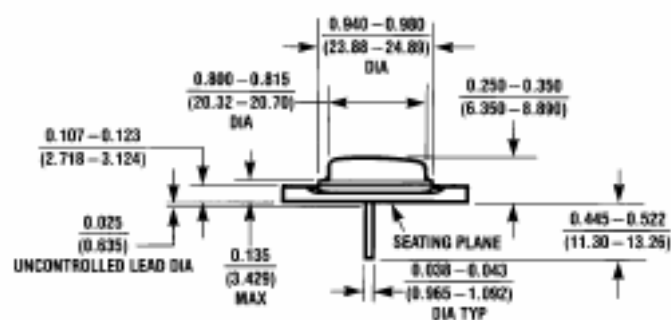
Top View

Order Number LM7805CT,
LM7812CT or LM7815CT
See NS Package Number T03B

TL/11/7746-1

LM78XX Series Voltage Regulators

Physical Dimensions inches (millimeters)



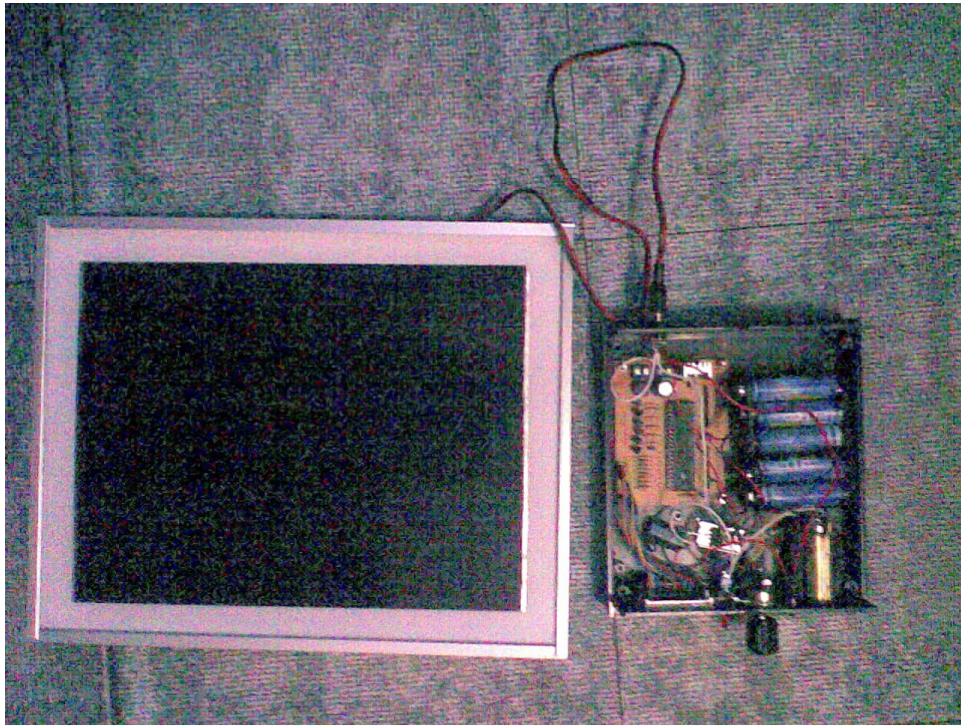
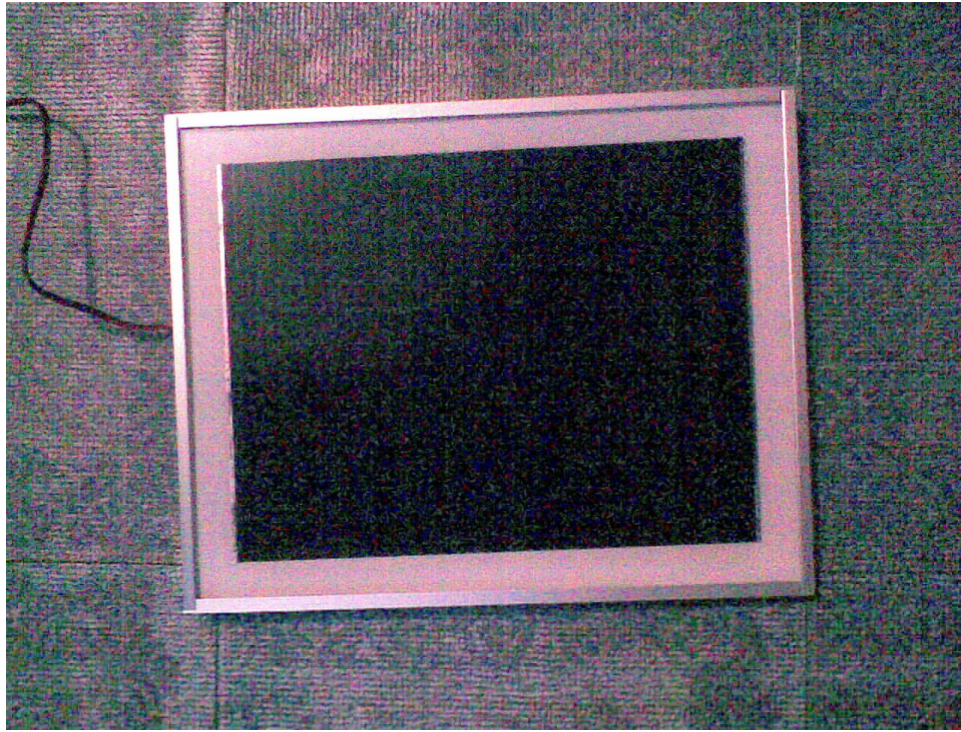
KC02A (REV G)

Aluminum Metal Can Package (KC)
Order Number LM7805CK, LM7812CK or LM7815CK
NS Package Number KC02A

APPENDIX E

Actual Photos of Solar Battery Charger



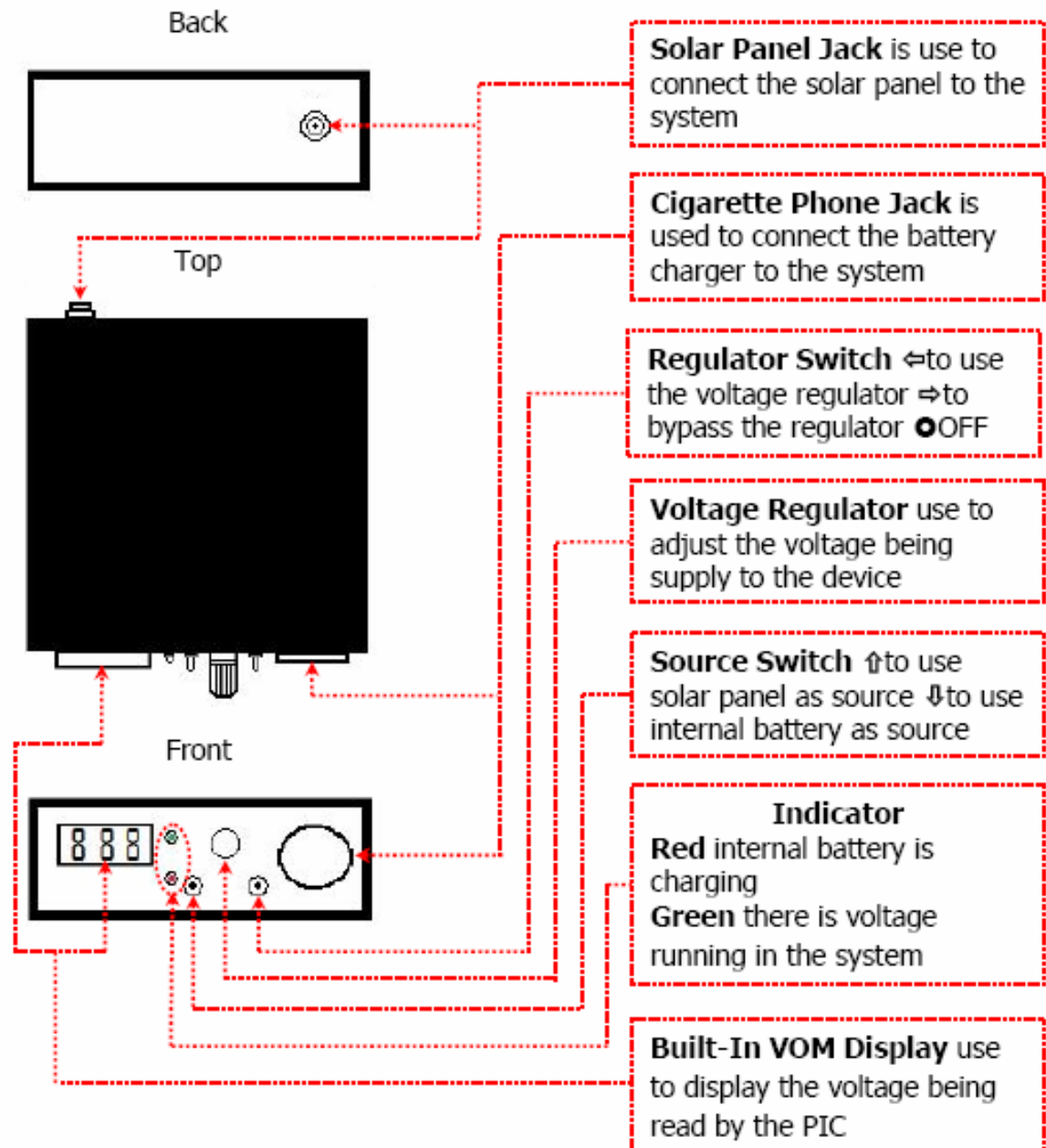


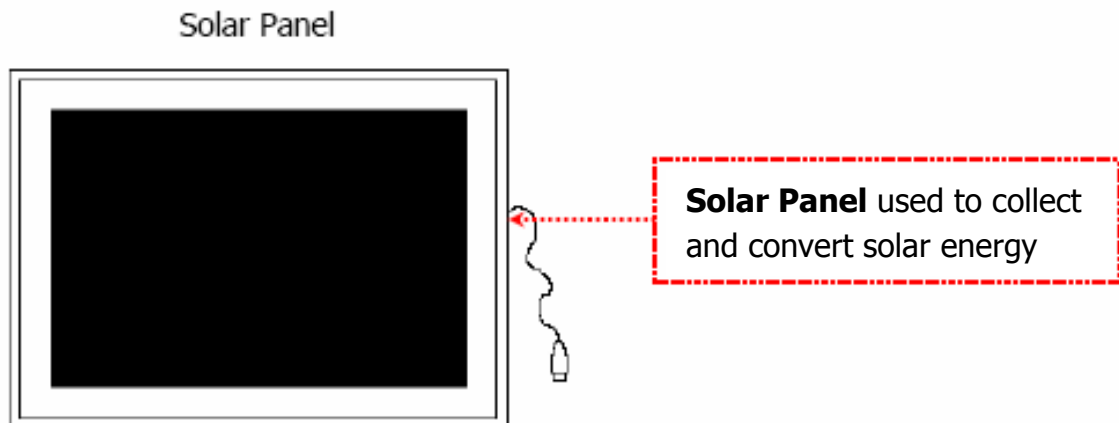




APPENDIX F

User Manual of Solar Battery Charger





Charging Using the Solar Panel

1. Connect the solar panel to the jack. Expose it to the sunlight.
2. Switch the source switch $\uparrow$.
3. Switch the regulator switch according to your choice (the green indicator must turn-on, this indicates that there is voltage being supplied to the system).
4. Connect the cellphone battery charger or any charger that is suitable to the cigarette phone jack.
5. If you choose to regulate the voltage, adjust the voltage regulator according to the voltage that is needed by the device, $\uparrow$ to maximize, $\downarrow$ to minimize.
6. Connect the device to the charger. Disconnect when battery is full.

NOTE: If the device is not charging, try to adjust the voltage regulator, or try to expose the solar panel to a better place where it can gather more solar energy.

Charging Using the Internal Battery

1. Switch the source switch $\downarrow$.
2. Follow procedure no. 3-6.

NOTE: Make sure that the battery has enough voltage to charge the device. To check, switch the switch regulator to bypass and read the voltage that the internal battery has using the built-in VOM display. If the internal battery has no enough charge, follow the procedure below (Charging the Internal Battery Using the Solar Panel) to charge it using the solar panel:

Charging the Internal Battery Using the Solar Panel

1. Connect the solar panel to the jack. Expose it to the sunlight.
2. Switch the source switch↴. This is done to make sure that the internal battery is connected to the system.
3. Position the solar panel in an area where there is enough direct sunlight.
4. Notice if the red light is on to indicate.
5. To check the charge, switch the switch regulator to bypass and read the voltage that the internal battery has using the built-in VOM display.

NOTE: If the battery is not charging (red light is off), it only means that the solar energy being collected by the solar panel is not enough to produce 12V. Try to expose the solar panel to better place where it can gather more solar energy.